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Price Leadership and Conscious Parallelism: A Survey

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Abstract

This survey of the recent analytical literature on price leadership shows that the identity and the characteristics of the leader are now well established. In a world without uncertainty, it is the most efficient but not necessarily the largest firm that is the leader. In a world with uncertainty, the best informed firm or the firm with the largest number of loyal customers is the leader.

With the help of repeated games, it is possible to determine the time path of the prices, characterised by rapid adjustments on the leader. An important conclusion emerges with regard to competition policy: price parallelism cannot be used as proof of tacit collusion.

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1. Introduction

The invasion of economic theory by game theory does not seem to have spared any part of microeconomic theory. In this article, I intend to give an account of the beneficial contributions of this invasion for a better understanding of parallel behaviour and its more or less collusive nature. Inevitably, attention will be focused on price leadership[1] which is frequently observed in oligopolistic markets[2].

When leadership is mentioned the Stackelberg model comes to mind. Two firms have quantity strategies and the leader increases his market share (and his profit) by anticipating the follower's behaviour (who takes the leader's output as given). Unfortunately, this model does not adequately explain parallel behaviour such that the announcement by a firm of a new price is very quickly adopted by its competitors. On the one hand, the sequential character of these announcements is neither modelled nor explained. On the other hand, the identity of the leader remains undetermined: the two Stackelberg firms both want to be the leader.

Can one define a non-cooperative equilibrium which incorporates sequential decisions and in which the identity of the leader is endogenous? In the following, I shall describe the progress made, step by step, in order to answer this question. Quite naturally, the first analytical efforts used static games (with or without uncertainty). More recently, the problem has been re-examined in a repeated game framework.

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[1]I limit myself to the case where a <u>single</u> firm announces a price, followed quickly by the other competitors. Therefore, I do not consider the situations of collusive price leadership where a <u>group</u> of dominant firms is followed by a competitive fringe. The conditions in which such groups can be formed and can be maintained are examined, for example, by Markham (1951), Oxenfeldt (1952), Lanzillotti (1957), d'Aspremont *et al* (1983) and Sleuwaegen (1985). Shaw (1974) discusses the difficulties of leaders, faced with new entry, in the UK petrol industry. The welfare losses associated with these situations are empirically evaluated by Gisser (1984 and 1986), Dickson (1988), Gisser (1988), Willner (1989) and Gisser (1989) for the US. The legal concept of "collective dominance" used recently by the European Commission with reference to article 86 of the Treaty of Rome, seems to correspond to the concept of collusive leadership of the above mentioned economists (see "Re Italian Flat Glass," *Common Market Law Report,* 1990, 4, 535). Naturally, I will discuss non-cooperative equilibria of the leader-follower type which imply collusive profits.

[2]Several cases of price leadership in the US are well documented in Scherer and Ross (1990, Chapter 7). On Europe, see Bourdet (1988, pp. 177–188) and Kirman and Schueller (1990) on the automobile industry and Phlips (1962, Ch. 8) on photographic products. Fog (1960) analyses a great number of Danish industries. The newspaper industry in Sidney is analysed by Merrilees (1983).

This dynamic approach illustrates the role played by pre-play conventions on the policy to be followed during the game. It will be shown that price parallelism over time which characterises price leadership is facilitated by an implicit convention between the players, according to which they agree to adopt the same rule of behaviour. This rule says that each one will align to the other as soon as a price rise is announced by one of the players. An important distinction is thus made between a "pricing policy" agreed upon before the beginning of the game and the fixing of a particular price in the course of the game. (In legal terminology, this convention is what one calls a "concerted practice" facilitating collusion). Spatially, the adoption of a rule of alignment on prices calculated from multiple basing points plays the same role. I could not resist the temptation to devote a final section to this spatial pricing policy. Particular attention will be given to the implications for competition policy, as pursued by the European Commission, the more so as the convention on spatial alignment is rendered obligatory (sic!) by the Treaty of the European Coal and Steel Community (ECSC) in the coal and steel industry.

2. Static Games without Uncertainty

Let us, to begin with, confine ourselves to a world without uncertainty and pinpoint some studies that have deepened Stackelberg's contribution while remaining faithful to the assumption that the players use either quantity strategies or price strategies. Under what conditions would a duopolist have an interest in being the first to move given this assumption? Gal-Or (1985) shows that this depends on the slope of the reaction functions. If these functions are both decreasing, as in the case of quantity competition between homogeneous products where the strategies are negatively correlated, the leader makes more profit than the follower. If these functions are both increasing, as in the case of price competition between differentiated substitutes where the strategies are positively correlated, it is the follower who makes the largest profits. In the first situation, each firm prefers to be the leader. In the second situation, each firm prefers the other to be the leader, if both firms have similar profit functions. This is Dowrick's (1986) point. In other words, if both firms have positively sloped reaction functions, the Stackelberg game has a reasonable solution only if the firms are sufficiently asymmetric in terms of costs and demand, such that one will prefer to lead. With decreasing reaction functions, they will fight to be the leader.

Clearly, the preceding analysis does not entirely answer the question of who will be the leader. Just because one firm wishes to be the leader, that does not imply that the other firm will agree to be the follower. If the two firms prefer to lead (or follow), neither can claim the preferred role. And even if the two firms agree that one of them should lead, it remains to be shown that this solution is the relevant non-cooperative equilibrium rather than a non-cooperative equilibrium with simultaneous actions. This is why Hamilton and Slutsky (1990) analyse an extended game where the players must choose both an action and the date of this action. If the firms have to carry out the action for which they have chosen a date, sequential results are obtained for non-dominated strategies. However, if the firms choose the date but need not specify the action they will take when they choose to lead, the equilibrium will result in simultaneous actions unless the resulting profits from the sequential actions Pareto dominate, that is to say, unless the two prefer the same sequential action to a simultaneous action. The existence of leader-follower type equilibria is thus well established. The equilibria typically arise in asymmetric cases where the firms are different and where they use price strategies.

I do not wish to explore these generalities any further, but rather specify, in more detail, the asymmetries and further enlarge the set of feasible strategies, for example[3] by combining price and quantity strategies. In this respect, Ono's approach (1978) appears exemplary: it uses more realistic assumptions and leads to precise results (at the cost of a loss in generality).

Ono assumes that the follower fixes a price infinitesimally smaller than that of its competitor and determines his output under the assumption that he is facing the entire demand of the market at this price (the products being homogeneous). The leader knows that the follower acts in this way and determines his price and output with respect to his individual demand curve. The latter is obtained by subtracting the rival output from the market demand curve.

We can represent the (downward sloping) market demand curve by $x = D(p)$. If the leader (firm 1) fixes a price p, then the follower (firm 2) determines its output such that $p = C_2'(x_2)$ where $C_2'(x_2)$ is the (convex) marginal cost. The output of the follower is therefore

$$x_2 = C_2'^{-1}(p) \qquad \text{if } C_2'(0) < p \leq C_2'\{D(p)\}. \qquad (1)$$

[3]Anderson (1987) shows, in the framework of the Hotelling model, that the introduction of the spatial dimension makes it possible to endogenise the Stackelberg leader.

The follower monopolises the market if $p > C_2'\{D(p)\}$. The individual demand curve of the leader is thus

$$\begin{aligned} x_1 &= D(p) && \text{if} \quad p \le C_2'(0) \\ x_1 &= D(p) - C_2'^{-1}(p) && \text{if} \quad C_2'(0) < p \le C_2'\{D(p)\} \\ x_1 &= 0 && \text{if} \quad p > C_2'\{D(p)\}. \end{aligned} \tag{2}$$

From these assumptions, Ono (1978 and 1982) obtains the following results for homogeneous products[4]:

1. If one of the firms has sufficiently low marginal costs such that the optimal output of any other firm choosing to be leader is sufficiently small, it is more profitable for this firm to be the leader. Moreover, when a firm makes more profit as leader than as follower, all other firms prefer to follow. Put more simply, "sufficiently inefficient" firms prefer to follow whilst the "sufficiently efficient" firm prefers to lead. This implies that a Stackelberg war is impossible in equilibrium.

2. When each firm has the same marginal cost, they all prefer to follow.

3. All firms which accept to lead can obtain a greater profit than in the Nash equilibrium. Thus there is a common disadvantage when all firms try to act as a follower vis-a-vis the others.

Ono (1982) notes that the firm which leads voluntarily is not necessarily the one which has the largest market share. Figure 1 illustrates this possibility. Firm 1 has the lowest marginal cost and will therefore be the leader. *MN* is the market demand curve. The residual demand curve of the leader is *ST*, obtained by horizontal subtraction of the marginal cost of the follower MC_2. The point where marginal revenue (MR_1^1) equals marginal cost (MC_1) gives the price *B*, for which firm 1 receives the profit *ABDE* (whilst the follower makes the profit *ACF*). At the leader's price, B, the leader's market share, *AB*, is smaller than the follower's, *AC*. When examining the profits that firm 2 could make as the leader, it can be seen that it is in the interest of firm 1 to be the leader and of firm 2 to be the follower. Firm 2's residual demand curve would be *QR* and its marginal revenue would be MR_2^1, so that it would fix price H and would gain profit *GHKF*, which is smaller than *ACF*. In this case, firm 1 would only obtain $GLE < ABDE$.

[4]He obtains analogous results for differentiated products.

Like Ono, Boyer and Moreaux (1986, 1987) endow firms with price and quantity strategies. However, they do this for both duopolists, while only the follower is allowed two strategies in Ono's approach, the leader having to be satisfied with fixing the price. Boyer and Moreaux (1987, note 4) criticise this assumption in the following words: "Why would the leader give the follower the possibility of acquiring the market share that the latter prefers? This is a privilege that the leader gives to the follower and is contrary to the interests of the leader. No valid justification of such a philanthropic behaviour is given by Ono." I do not understand this criticism. The possibility of appropriating the market share that is optimal for the follower (including the whole of the market) with an infinitesimal price decrease, results from the homogeneity of the product and has nothing philanthropic about it. Given this homogeneity, the interest of the leader is to put itself on its residual demand.

In the models of Boyer and Moreaux, each firm fixes a price and decides to "offer" a certain quantity, in the sense that at this price it is willing to sell this quantity or less (but not more). There is, therefore, a possibility of rationing, each firm being able to put itself below its demand function. This assumption is supposed to correspond to observed business behaviour. "Rare, indeed, are firms who would accept to sell a certain quantity whatever the market price, which is what an output strategy ultimately implies . . ." (Boyer and Moreaux, 1986, p. 57). Here again it is difficult to understand. What I do understand is the remark made by Friedman (1983, pp. 47–48) that car manufacturers are obliged to plan their production in advance and subsequently to fix a price that the market will accept. It is in this way that output strategies can be interpreted in business practice. I also note that the choice of the rationing scheme remains entirely arbitrary: random rationing is postulated for the sole reason that it is simple! I finally note that, in practice, firms try to avoid having to ration their customers, because a rejected customer is a lost customer[5].

Whatever the case, let us consider what type of equilibrium the assumption of demand rationing leads to. As in the Ono model, when the costs of production are identical or similar, both firms prefer to be the follower. If, to the contrary, there is a substantial cost difference, the non-cooperative equilibrium can only be of two different types. In one case, the least efficient firm behaves as leader and sells a limited quantity at a low price, whilst the most efficient firm behaves as a follower and sells to the residual demand at a higher price. In the other case, the

[5]Delivery delays which are typical for certain makes of car (Mercedes!) can be interpreted as a marketing device to maintain the car's image.

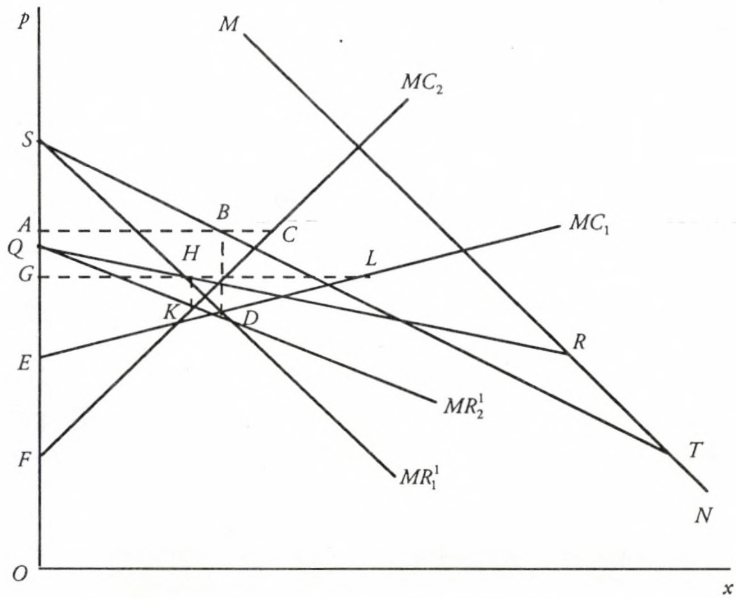

FIGURE 1

Source: Ono (1982).

most efficient firm eliminates the other by adopting a limit-price strategy. In doing so, it receives a lower profit than if it had behaved as a follower. To sum up, this is the world upside-down, the intuition being that the poor buyers who are not served by the leader will be exploited by the follower.

3. Static Games with Uncertainty

The results obtained by Ono in a static world without uncertainty (and where the players are perfectly informed) are already very satisfying. Let us nevertheless see how the analysis can be refined by confronting the players with imperfection information. I will first introduce demand uncertainty. Secondly, I will examine how the Stackelberg leader emerges when production costs are uncertain. Finally, I will examine the role a group of loyal customers, who cannot be distinguished from price sensitive consumers, may play.

Let us assume that the firms are confronted with both a random market demand and an uncertain market share. When an economic shock (for example, a recession) occurs, it is immediately reflected in their sales and in their stocks. For the individual firm, the reason for this is not clear: is the unexpected fall in sales due to a shift in the market demand function or is it due to a random variation around an unchanged function? In order to detect the shock, the firm must estimate market demand. But for this, its own sales are the most immediate source of information.

Eckard (1982) thinks that the smaller the market share of the firm, the greater the variance of its estimate will be, in view of the uncertainty about the evolution of its rivals' sales (and, therefore, about its own market share). In fact, rival competition generates statistical "noise" which reduces the precision of its estimate. The probability of detecting the shock (and of a suitable reaction in price) is therefore greater for the firms who have the relatively larger market shares.

From here, the transition towards a leader-follower model is immediate: on the one hand the largest firm is the most likely to be the first to detect the shift in market demand; on the other hand, the smaller firms observe the price reactions of the large firm, in order to get valuable information for their own market analyses. The small firms profit from the largest firm's ability to generate the most efficient information.

This information is a public good which the leader provides to the whole industry. It remains to be seen whether the leader has an interest in obtaining this information, given that the gathering of information has a cost. Higgins *et al.* (1989) show that this is indeed the case. They assume that the industry is composed of r factories of equal size and that the dominant firm controls t of these. As in the Ono model, the small firms adopt the price fixed by the dominant firm and determine their sales by equalising their marginal cost with this price. Their global offer O^f is $(r-t)p/c$. The cost function of the dominant firm is $(c/2t)(D-O^f)^2$, where $D=A+bp$ is the market demand and $A=(X_1+\cdots+X_n)$. Given O^f (known) the leader's residual demand is $D-O^f=A+[bc-(r-t)]p/c\equiv A+Bp$. A is uncertain.

The variables X_i are random, identically and independently distributed variables with mean μ/n and variance σ^2. The dominant firm can know m among the X_i at a search cost of $(d/2)m^2$.Hence its profit function is

$$\begin{aligned}\pi &= (D-O^f)p-(c/2t)(D-O^f)^2-(d/2)m^2\\ &= A(1/t)(t-cB)p+(1/2t)(2t-cB)Bp^2-(c/2t)A^2-(d/2)m^2.\end{aligned} \tag{3}$$

In a first stage, the expectation (conditional on the information obtained) is maximised to determine the optimal price p^*. Using this result, the unconditional expected profit

$$E^*(\pi)=\gamma(\mu^2+m\sigma^2)-(c/2t)\eta\sigma^2-(d/2)m^2 \tag{4}$$

is maximised, in a second stage, to determine the optimal size of the sample m.

One obtains

$$\begin{aligned}&m^*=\gamma\sigma^2/d,\\ &\text{where } \gamma=-(1/2tB)(t-cB)^2/(2t-cB).\end{aligned} \tag{5}$$

A similar calculation is made for the small firms. Their expected profit turns out to be an increasing function of m. The more precise the pricing policy of the dominant firm, the more profits they will make. Consequently, as Eckard had already noted, the variability of prices increases with the market share of the leader[6].

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[6]According to Holthausen (1979), price variation is greater when the firm is less risk averse.

Note that in the Stackelberg game (using quantity strategies) where the leader has private information about the state of the market demand, this information is also revealed to the follower through the leader's output. Gal-Or (1987) shows that, in a linear world, the inferences made by the follower increase the slope of its reaction function. This slope can even become positive if, at the time the follower revises its a priori beliefs, it gives sufficient weight to the quantity produced by the leader. Consequently, it is not necessarily true that the leader makes more profit than the follower, as was the case when there was perfect information (see above).

Consider uncertainty about the costs of production in a static non-cooperative duopoly game. Assume that the two firms neither know their own marginal cost nor their rival's. However, they both know the parameters of the distributions from which these costs are drawn at the time when they agree on the distribution of roles (leader or follower). (In case of a disagreement, they will play the relevant Nash game). When they then decide on their output, they know their own but not their rival's marginal cost.

It is with this information structure that Albaek (1990) proves the existence of a "Natural Stackelberg Situation" (NSS). Since it implies an agreement, there is a cooperative aspect to it. But, this is only apparent: true cooperation — in particular an exchange of information — is excluded. The idea is to calculate the expected profits for the three possible outcomes: leader, follower or Nash, before the firms know their marginal cost. A NSS exists when one of the firms has the greatest expected profit as leader and the other as follower. A NSS does not exist when pricing strategies are used. Albaek emphasises that the solution does not depend on the substitutability or the complementarity of the products. Even when there is complementarity, a firm can still wish to be leader, because the strategic disadvantage of the leader can be compensated by better coordinated responses to cost variations. In the case of substitutability, it is the strategic disadvantage of the follower which can be compensated by the information it obtains on the costs of the rival.

It remains to introduce the role that customer loyalty can play in determining the identity of the leader. Deneckere *et al.* (1992) assume that two firms produce a non-durable differentiated product at zero cost. The consumers, who buy at the most one unit from one of the firms, are partitioned into three groups. In the first group, firm 1 has n_1 loyal consumers, in the sense that they buy one unit of its product if its price is $p_1 < r$, the common reservation price. The second group consists of n_2 consumers who are loyal to firm 2, and are defined in a similar way. The third group is composed of m consumers who buy at the lowest price (as long as it is less than r). The two firms know the value of n_1, n_2 and m but do not know which group a consumer belongs to (so that they cannot price discriminate).

The profit of firm i (i=1,2) is therefore

$$\pi_i(p_i, p_j) = \begin{cases} L_i(p_i) = (n_i + m)p_i & \text{if } p_i < p_j \\ T_i(p_i) = (n_i + D_f^i m)p_i & \text{if } p_i = p_j \\ H_i(p_i) = n_i p_i & \text{if } p_i > p_j \end{cases} \tag{6}$$

on the assumption that the third group buys from the follower when prices are equal, so that $D_f^i = 1$ if i is the follower and $D_f^i = 0$ if i is the leader. If $n_1 > n_2$, firm 1 has equilibrium profits $\pi_i = n_i r$ if it acts as either leader or follower or as a result of playing a simultaneous game (so that $\pi_1^L = \pi_1^F = n_1 r$). This firm is therefore indifferent between the three situations. To the contrary, firm 2 (which has the smallest segment of loyal clients) prefers to follow (so $\pi_2^F = (n_2 + m)r$) and is indifferent between leading and playing simultaneously (its profit then being $\pi_2^L = ((n_2 + m)/(n_1 + m))n_1 r < \pi_2^F$). In equilibrium, $p_1 = p_2 = r$ when firm 1 is the leader. If firm 2 leads, it attracts the third group at the cost of a lower price $p_2 = n_1 r \quad (n_1 + m)$ but firm 1 keeps the price $p_1 = r$ and therefore continues to sell only to its own customers.

In order to show that firm 1 is the endogenous leader, Deneckere *et al.* construct a game in which the optimal date of the price announcements is determined. The time period considered is the unit interval [0,1], divided into T (T even) periods of length $\tau = 1/T$, where $t = 0, \cdots, T-1$. Firm 2 may announce its price at the beginning of intervals with an even index and firm 1 may announce at the beginning of intervals with an odd index[7]. There is a cost of waiting, so that profits are discounted using a discount factor $\delta = e^{-\rho t}$.

Proceeding backwards, firm 2 announces its leader price, p_2, at time T–2 since that is the last date at which it can fix a price. No price is announced previously. Firm 1 follows at T–1 by announcing its follower price p_1. The discounted equilibrium profits will be $\delta^{T-1}\pi_2^L$ and $\delta^{T-1}\pi_1^F$ respectively. At any

[7]The prices are fixed only once and remain in force for the duration of the unit interval rather than for a particular period. Profits only materialise after the moment when the <u>two</u> firms will have made their announcements. These restrictions can be relaxed: see Deneckere *et al.* (1992, p. 154).

period t (for $t=1,3,\cdots,T-3$) no price having previously been announced, firm 1 must compare $\delta^{t+1}\pi_1^L$ to $\delta^{t+j+1}\pi_1^L$ (if it leads at $t+j$, except when $t=T-3$, since then the profit of the leader is zero at $t+2$) or to $\delta^{t+j}\pi_1^F$ in case it follows at $t+j$ ($j>2$, even). However, we know that $\pi_1^L=\pi_1^F$. Firm 1 will therefore always announce its leader price at the first opportunity (so long as no price has been previously set). As for firm 2, it must therefore, at $t=0,2,4,\ldots,T-4$ compare $\delta^{t+1}\pi_2^L$ to the profit it would have earned after having waited for the announcement of firm 1, that is $\delta^{t+2}\pi_2^F$. If $\left(\pi_2^L/\pi_2^F\right)<\delta$ it prefers to wait. However, $\pi_2^F>\pi_2^L$. For a sufficiently large discount factor δ, firm 2 will always wait until firm 1 has fixed its leader price at $t=1$, and fix its follower price at $t=2$. Firm 1 is an endogenous leader.

It is clear that this model enables us to understand why, in an international context (for example within the Common Market), national firms emerge as leaders in their respective national markets to the extent that patriotic feelings ensure them more loyal customers.

The chronological order of the events is explicitly taken into account in the preceding paragraphs but the equilibrium prices announced at a certain date are the result of an instantaneous game. The time has come for us to turn towards a dynamic approach in which the time shape is incorporated in the basic model. A repeated game appears to be the simplest approach to take.

4. A Repeated Game

The pricing policy examined here is often observed in oligopolistic markets. Often, there is one firm which announces a price change some time before the date at which the new price will be valid. This date, as well as the new price, are adopted after a brief delay by the other firms. The new price is often accepted as such, even when the products are differentiated, so that all the rival firms make the same announcement within a short time period[8]. The question to answer is whether collective behaviour of this type can lead to collusive results in the absence of explicit collusion. The answer of Rotemberg and Saloner (1990) is affirmative.

[8]Often as well, a considerable time period separates the dates at which the prices change. This price "rigidity" should not be confused with a small variability (which depends on the size of the price variation). Rotemberg and Saloner (1990, pp. 100–104) show that such a rigidity can reduce the difference between the profit of the leader and that of the follower (which occurs when the leader changes price too often).

The model has two firms producing good 1 and good 2 respectively at a constant marginal cost c. The demand curves of these firms are

$$\begin{aligned} q_1 &= x - bp_1 + d(p_2 - p_1) \\ q_2 &= y - bp_2 + d(p_1 - p_2). \end{aligned} \tag{7}$$

They are symmetric, apart from the intercepts x and y. These parameters fluctuate over time. Define $a \equiv (x+y)/2$ and $e \equiv (x-y)/2$. Hence, equations (7) become

$$\begin{aligned} q_1 &= a + e - bp_1 + d(p_2 - p_1) \\ q_2 &= a - e - bp_2 + d(p_1 - p_2). \end{aligned} \tag{8}$$

The change in variables gives a common component, a, which affects the level of the two demands in the same way, and an idiosyncratic component, e, which increases q_1 by the same amount as it decreases q_2.

The information structure is the following. Firm 1 knows the values of a and e whereas firm 2 knows only their distribution, as well as the history of the prices and the quantities. When a and e are distributed independently, this history does not give any information about the current value of a and e. As a consequence, firm 2 only knows the unconditional means, which are a' and zero. Firm 1 is unable to communicate its information in a credible way.

If the information had been perfect, the firms would have been able to maximise joint profit, that is $[q_1(p_1 - c) + q_2(p_2 - c)]$, which would have led them to announce two different prices

$$\begin{aligned} p_1 &= [a/b + c + e/(b+2d)]/2 \\ p_2 &= [a/b + c - e/(b+2d)]/2 \end{aligned} \tag{9}$$

and to obtain a global profit of

$$R = (a - bc)^2/2b + e^2/(2b+4d). \tag{10}$$

In reality, they play a non-cooperative repeated game whose collusive result can be sustained at equilibrium by the credible threat of a price war if one of them deviates from the agreed pricing policy. The collusive outcome results from an implicit preliminary agreement on the following pricing policy: at the beginning of each period, firm 1 announces its price for this period, to the extent that firm 2 has not previously deviated; firm 2 next announces the same price that period; if firm 2 should announce another price, an infinite price war would ensue, in the sense that in all following periods the announced prices would be the equilibrium prices of the corresponding static (single period) price leadership game.

At the equilibrium of the repeated game, firm 1 is certain its price is also that of the other $(p_1 = p_2 = p)$. Its profit for each period is therefore

$$R_1 = (p-c)(a+e-bp) \tag{11}$$

and in equilibrium

$$p^* = c/2 + (a+e)/2b \tag{12}$$

$$R_1^* = (a+e-bc)^2/4b. \tag{13}$$

For the follower,

$$R_2 = (p-c)(a-e-bp) \tag{14}$$

and in equilibrium

$$R_2^* = (a+e-bc)^2/4b - (a+e-bc)e/b \tag{15}$$

so that the global profit is

$$R^* = R_1^* + R_2^* = (a-bc)^2/2b - e^2/2b, \tag{16}$$

which is less than the maximised joint profit R in (10) for e non zero. Note that if e is always equal to zero (the unknown level of demand is the same for the two firms), then $R^* = R$ and $R_1^* = R_2^*$: the two firms make the same profit and firm 1 chooses the price which maximises the joint profit.

When e is different from zero, firm 1 fixes a price which raises its profit at the expense of overall industry profits. Then the average values of (15) and (16) decline as the variance of e rises: the expected profits of firm 2 and of the industry are decreasing in the variance of e. This gives firm 2 a specific motive to deviate from the agreed policy by announcing a lower price. It can be shown that, in fact, it will not deviate when orthodox behaviour ensures a higher profit than the expected profit from a deviation followed by eternal punishment.

Price leadership by firm 1 is endogenous when the variance of e is sufficiently small with respect to the common variance of market demand. Indeed, the difference between the expected profit of firm 2 when firm 1 acts as leader and its expected profits when it acts itself in this capacity is

$$\left[E(a-a')^2 - 3Ee^2\right]/4b. \tag{17}$$

The variance of a must be at least three times that of e.

5. Price Parallelism and Collusive Practices

In terms of observed behaviour, the pricing policy analysed above leads to parallel price variations. MacLeod (1985) shows that it is possible to generalise this result for a market composed of n firms on certain conditions. Proof is thus given that a social convention to adopt a policy of parallel price variations leads towards collusive profits that are between those of a static Nash equilibrium and those resulting from the full maximisation of joint profits, given non-cooperative behaviour.

Let $\underline{P} = (p_1, p_2, \cdots, p_n)$ be the vector of prices charged by the industry. Suppose also that the firms can announce the prices that will be applicable in the following period in advance and that firm i announces a variation Δp_i. Firm i can be any firm.

The firms do not know the profit functions of their rivals, but they can observe the prices of the previous periods as well as the announced price change. They tacitly adopt the convention to react to the announcement according to an alignment rule, independent of the profit functions, which is written as

$$\Delta p_j = r_j^i(\underline{P}, \Delta p_i), \qquad j \neq i. \tag{18}$$

MacLeod demonstrates that the agreed alignment is defined by

$$r_j^i(\underline{P}, \Delta p_i) = \Delta p_i, \tag{19}$$

that is to say by price changes equal to those announced by i, when three conditions are satisfied. The alignment rule must

1. be continuously differentiable;

2. be independent of scale changes (for example inflation), that is $r_j^i(\alpha \underline{P}, \alpha \Delta p_i) = \alpha r_j^i(\underline{P}, \Delta p_i)$ for all i, j and $\alpha > 0$;

3. be independent of the order in which the firms are indexed.

Convention (19) is independent of profits and leads nevertheless to tacit collusion in a signalling game where the players adopt the following strategy: (1) When a price increase is announced, follow it if it is profitable to do so and if the others do the same; otherwise, do not change the price; (2) when a price decrease is announced, follow it as long as it does not lead to prices lower than the prices $\underline{P}^0$ which would result in a static Nash equilibrium; (3) if any rival firm does not behave according to (1) and (2), announce the punishment price $\underline{P}^0$. If each firm adopts this strategy, there exists a non-cooperative equilibrium with prices $\underline{P}^*$ higher than $\underline{P}^0$ and lower than the prices which would maximise the joint profit on condition that the products are sufficiently close substitutes so that a unilateral price increase leads to a loss of profits. The price $\underline{P}^*$ results from parallel price increases thanks to convention (19), which ensures that the expectations about the rivals' reactions are correct.

Convention (19) is therefore a "concerted practice"[9]. It makes "tacit" collusion possible, tacit collusion being nothing other than a collusive outcome obtained in a non-cooperative repeated game. The convention itself does not imply an explicit agreement. This explains the difficulty which the authorities in charge of competition policy (for example, in the enforcement of articles 85 and 86 of the Treaty of Rome), have in proving its existence. Can these authorities deduce the existence of a concerted practice, forbidden by article 85, paragraph 1 from the observation of parallel price variations? In other words, can they distinguish between the static Nash equilibrium $\underline{P}^0$ and the collusive equilibrium $\underline{P}^*$? The

[9]Under the law of the Community, a concerted practice implies the existence of a common will that does not necessarily result from a legally binding agreement. See especially the judgments of the Court of Justice of the European Communities on 14 July 1972, ICI (48/69, *European Court Reports*, p. 619), BASF (49/69, *ECR*, p. 713), Bayer (51/69, *ECR* p. 745), Geigy (52/69, *ECR* p. 787), Sandoz (53/69, *ECR* p. 845), Francolor (54/69, *ECR p. 851),* Cassella (55/69, *ECR* p. 887), Hoechst (56/69, *ECR* p. 927), ACNA (57/69, *ECR* p. 933); judgment of the 16 December 1975, Suiker Unie e.a. (40 to 48, 50, 54 to 56, 111, 113 and 114/73, *ECR* p. 1663); judgment of the 7 June 1983, Musique Diffusion Française (100 to 103/80, *ECR* p. 1825); judgment of the 28 March 1984, CRAM and Rheinzink (29 and 30/83, *ECR* p. 1679); judgment of the 14 July 1981, Züchner (172/80, *ECR* p. 2021), judgment of the 10 December 1985, Stichting Sigarettenindustrie (240, 241, 242, 261, 262, 268 and 269/82, *ECR* p. 3831).

answer is no. In the framework of the MacLeod model, the answer is negative for two reasons. First, for parallel price changes to be sustainable, the products must be sufficiently close substitutes. For such products a price change by one firm immediately affects the profits of the rivals, regardless of the initial price level. Hence, we must expect all firms to respond at the same time to exogenous shocks, regardless of whether tacit collusion is present or not. The simultaneous nature of price changes, therefore, is not proof of collusion. Secondly, as long as the profit functions are not known, there are no systematic differences between the size of price responses at the non-cooperative and collusive equilibria. In particular, the identity of the price variations is not a proof in itself.

It is therefore unfortunate that the European Commission uses price parallelism as a proof of tacit collusion, as in the "Wood Pulp" decision of 19 December 1984 (*Official Journal* no. L 85/1).

In 1981, six Canadian producers of wood pulp, ten American producers, eleven Finnish, six Swedish, one Norwegian, one Portuguese and one Spanish, plus the U.S. Pulp, Paper and Paperboard Association, the Finnish Sales Bureau and the Swedish Wood Pulp Producers' Association were informed that the Commission had proof of collusive behaviour relating to their export prices to the European Community. The essential part of the proof was the parallelism in the evolution of the prices between 1975 and 1981. Within a few hours or a few days, the announcement of a new price was followed by the competitors. In fact, the quarterly prices were announced to the customers and to the agents of the producers a few weeks before each new quarter. As a consequence, the prices announced were identical in the North-West of Europe and almost identical in the South of Europe. Scarce were the buyers who benefited from a discount. All the announcements were in American dollars (and not in the member countries' national currencies). The majority of the producers were condemned to fines from 50.000 to 500.000 ECU.

In *The Economics of Imperfect Information* (pp. 183–193), I indicated how the Commission's concept of "normal" or "active" competition diverges from elementary game theory. May it suffice to say that the Commission is wrong when it excludes that observed parallelism could be explained without collusion[10]. Since wood pulp is a strongly homogeneous product, identical and simultaneous price

[10] A certain number of producers appealed against the decision of the European Commission at the Court of Justice of the European Communities. In his conclusions presented on the 7th of July 1992, Attorney-General Marco Darmon expressed the same opinion as the one put forward here.

changes are not surprising and even inevitable with or without a rule of alignment. This is the more so as price information circulates extremely quickly between producers, agents and consumers of pulp. Paper producers exchange all information on the announced prices in a matter of hours. They also inform pulp producers, through their agents, about the prices announced by their rivals. (In game-theoretic terms, the history of the game is perfectly known).

Two remarks will be added of which the first is particularly important in the wood pulp case. The demand for pulp has a pronounced seasonal character. The quarterly nature of the announcements is nothing special and does not suggest collusion. To announce new prices in advance does not imply, either, that an alignment rule exists. When stocks are important, as they are in the wood pulp industry, announcing a price increase in advance can simply create incentives to buy without delay. This smoothes out the orders and transfers the storage cost from the seller to the buyer.

The wood pulp case is a striking example of the difficulties that the anti-trust authorities encounter when they suspect the existence of an alignment rule. Everybody can follow the rule without any formal agreement. And nobody can deduce from observed parallelism that such a rule has been followed.

The previous discussion focused on intertemporal alignments. It would have been possible to stop the discussion here, if there had not been a striking analogy with the spatial alignment rule which characterises the basing point price system.

6. The Basing Point System in the ECSC[11]

In this final section we move to the spatial domain and try to show why the multiple basing point price system imposed by the Treaty of the ECSC implies a concerted practice that facilitates tacit collusion, exactly as the intertemporal alignment rule (19) does.

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[11] This section reproduces part of my paper "Basing Point Pricing, Competition and Market Integration" to appear in H. Ohta and J.-F. Thisse, *Does Economic Space Matter? Essays in Honour of Melvin Greenhut*, Macmillan, London.

First, a little history. Before 1951, the German and French steelmakers fixed their national prices according to a single basing point price system. Oberhausen was the only basing point for Germany. Thionville was the basing point for France. Consider Thionville: the biggest steel plants were located in and around that town. In all of France, the franco prices[12] were calculated by summing the base price at Thionville plus the transportation cost to a particular delivery point. This implies that the franco prices went up to the extent that steel was moved towards the South and the South-West. Note also that the franco price went down when steel was produced in the South and transported for delivery towards the North. In other words, the big Northern producers were able to sell anywhere in France, while the small Southern producers were constrained to sell in their local regional markets. But the South was compensated for this in terms of phantom freight collected in the vicinity of its plants. The system was meant to keep the Southern producers happy and small. In that sense, it was the equivalent of a national geographical market sharing agreement.

When a common steel market between the Benelux countries, France, Germany and Italy was envisaged, the problem arose of how to define a common pricing policy, such that the prevailing allocation of geographical markets could be maintained. An agreement was reached after long discussions between the steelmakers. Far from being implicit, it was as explicit as possible, since it was written down in article 60 of the ECSC Treaty and thus became obligatory for everyone! This is the more surprising as similar conventions were declared illegal by the American courts because contrary to anti-trust legislation.

Different possibilities were discussed. Should a fob-mill[13] pricing policy be imposed? In those days, economic theory considered this the only system compatible with a Pareto optimum. The big production centres didn't like it, because they would have lost access to peripheral regional markets. In particular, the Belgian steelmakers (who had to export more than half of their production) would have lost many export markets inside the common market, given their location between Thionville and Oberhausen at a short distance from these centres. Second, it is very difficult to compute and compare delivered prices in any given location under a fob-mill system, because of the large number of steel plants in the European common market <u>and</u> because buyers can use different means of

[12]The "delivered" price is the price at the point of delivery. It is called the "franco" price when it is directly fixed by the producers.

[13]This implies that the buyer must take care of the transportation from the factory and pay its full cost.

transportation (so that effective transportation costs vary from buyer to buyer). To enter a distant market, competitors would have had to grant secret price discounts. The end result would have been a series of regional price wars to avoid a loss of distant markets.

A single basing point system would have made it easier for the producers to compute the delivered price to be quoted in any location, given a particular means of transportation. But where to locate such a single basing point? Not in France, since that would have limited the geographical extent of German sales west and southwards. Not in the Ruhr area, for symmetric reasons. Not in Benelux or Italy: that would have made all other countries unhappy.

The only way to maintain the existing trade patterns inside and between the six countries was to create a multiple basing point system, characterised by an alignment rule. The alignment rule ensures that, at any geographical location, the delivered price to be quoted by all the competitors is equal to the lowest combination of a base price plus freight (to that location) calculated from all basing points existing in the system. (Since base prices differ, the lowest delivered price does not necessarily correspond to the nearest basing point). Thus at a given place of destination only a single delivered price is possible, identical, and known with precision regardless of the seller and regardless of the actual distance covered in carriage to the place of destination. Indeed, the freight to be added to the base prices is worked out from a published tariff accepted by all concerned, such as a railway company's schedule of charges.

The analogy with the intertemporal alignment rule (19) is clear. The intertemporal rule and the spatial rule both ensure unicity of prices at any point in time or space. Each rule makes the reactions of the competitors perfectly predictable. Furthermore, spatial alignment simplifies the life of a possible leader: if a firm i wants to be the leader, it suffices to announce a sufficiently low base price so that the other producers are obliged (by the alignment rule) to adopt the delivered price of the leader at all their selling points; in a similar way, it suffices, for the follower, to announce a sufficiently high base price so that it is never applied.

The convention written down in article 60 of the ECSC Treaty is clearly a concerted practice transformed into a binding legal agreement in full contradiction with article 85 of the Treaty of Rome. It creates conditions which sustain a non-cooperative equilibrium whilst ensuring collusive profits. In more simple terms, article 60 makes tacit collusion possible.

To see this, consider the functioning of the system. The obligation to align makes local price competition impossible. It is true that it guarantees a delivered price that is the lowest possible whatever the geographical location (the rules of the system, the base price and the transport tariff being given). Nevertheless, alignment has no competitive virtue. At first sight, the word alignment suggests aggressive behaviour. In reality, it is purely defensive, because it excludes the possibility of selling below the delivered price of the other firms. Given equal prices, the sellers can tie traditional pre-common-market customers to them wherever such customers may be located. The purpose is to freeze existing trade patterns and thus to leave market shares unchanged. Since alignment implies cross-hauls, the allocation of resources is less efficient than in the case of joint profit maximisation. The collusive profits made are therefore less than the profits resulting from explicit regional price agreements.

Figure 2 illustrates what has just been said and also shows that the alignment rule allows some interpenetration of markets without endangering the geographical price structure (that is to say, without provoking a price war). Space is represented on the horizontal axis. Points I and II represent basing points, where marginal costs are mc_1 and mc_2 respectively $(mc_1 < mc_2)$. The figure shows marginal delivered costs (marginal production cost plus unit transport cost). The announced base prices are p_1 and p_2 from which the corresponding delivered prices increase in both directions. Firms located at II sell westwards until point a and eastwards until point *h*. Firms located at I sell eastwards until point *c* and then from *f* till *j*.

The firms align on the delivered price calculated from a base point which is not their own along the segments *AB, BC, FG* and *GH*. Along *AB*, firms located at II align on p_1–plus delivered prices fixed by firms located at I (so that the delivered prices of firms II go <u>down</u> as they sell more toward I). Along *BC*, firms located at I align on the p_2–plus delivered prices fixed by firms located at II (so that their delivered prices go down as they sell more toward II).

These alignments ensure that a) I can sell in the segment *bc*; b) II can sell in the segment *ab*, and c) there will be no price competition pushing the delivered prices down to *ADC* inside the area *ABCD*.

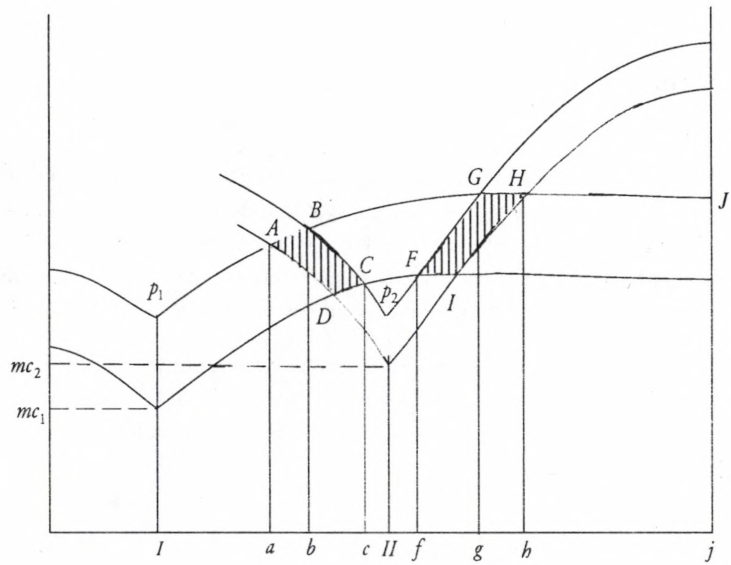

FIGURE 2

A similar argument applies to *FG* (where **I** aligns on p_2–plus) and *GH* (where **II** aligns on p_1–plus). Both centres enlarge their market area while avoiding price competition inside the area *FGHI*. Without the alignment rule, prices would have dropped to *FIH* along the segment *fh*.

Finally, cross-hauling occurs over the distance between *a* and *c*.

7. Conclusions

This survey of the recent analytical literature on price leadership has shown that the identity and the characteristics of a price leader are now well established. In a world without uncertainty, it is the most efficient but not necessarily the largest firm that is the leader. In a world with uncertainty, the best informed firm or the firm which has the largest number of loyal customers is the leader.

With the help of repeated games, it is possible to determine the time path of the prices, characterised by rapid adjustments on the leader. An important conclusion emerges with regard to competition policy: price parallelism cannot be used as proof of tacit collusion.

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